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LOW-POWER, LOW-SPEED DATA STORAGE AND PROCESSING TECHNIQUES <sup>7</sup>

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## PREFACE

The following is the twelfth Progress Report on the National Aeronautics and Space Administration Research Grant NsG-138-61, entitled "Low-Power, Low-Speed Data Storage and Processing Techniques." It covers the period between September 1, 1966 and March 1, 1967.

The work will be covered by descriptive reports outlining the progress and direction of the research and will state in simple terms the important conclusions. Detailed technical studies will be published in a series of Technical Notes as soon as they are completed.

Richard Clark Barker

Director

NASA NsG-138-61

Progress Report, September 1, 1966 - March 1, 1967

## STATEMENT OF OBJECTIVES

The purpose of this research is to improve the technical capability to perform memory functions in spacecraft. The study includes special purpose, preprogrammed memories, memories that perform data-analysis functions, and general-purpose memories, including content-addressed and command-addressed memories.

At the present time, the demands of spacecraft development schedules require early commitment to developed memories and well-established circuit techniques. The research covered by this grant is designed to bring together the newest techniques and materials in a manner relevant to spacecraft application so that improvements in memory designs can be realized from basic technical advances as rapidly as possible. The results should be applicable to a wide variety of spacecraft missions.

An important part of the study is to assemble information on a variety of memory techniques so that it will be available to NASA instrumentation groups and associated groups planning space experiments.

## SUMMARY OF WORK FOR THE PERIOD SEPTEMBER 1, 1966-MARCH 1, 1967

Memory Techniques

The design of a memory oriented data management system has continued, largely in the hands of H. K. Kim. We are considering the problem of incorporating a set of bit plane encoders into a telemetry system. We are considering the case of eight experiments encoded through a central encoding memory in a hypothetical system having the overall specifications of an AIMP satellite. Six of the experiments are clock synchronized and two are spin synchronized. Real-time data and fixed-format data, including synchronization and time, are provided for in the overall telemetry sequence. The block assigned to the bit-plane encoded data provides for adaptive sharing of time among the eight experiments, and provision is made for the transmission time of these eight to expand into the time used by the fixed-format experiments on a priority basis.

The above system is controlled by an instruction set and a program stored in a program memory. The program generates the basic telemetry sequence, and regulates the loading, monitoring, and encoding of the six experiments into segments of the data processing memory. All data is reformatted into 8 bit words for transmission.

So far, we have worked out the algorithms for control of the telemetry sequence, the instruction set, and the program for carrying out the sequence. This includes monitoring the bit plane encoded experiments, selecting the encoding options, and removing lower order bits for total bit-rate control.

The problems to be solved are: 1. the buffer design, 2. the use of buffer level as a method of total bit rate control as opposed to scanning the data before processing into the buffer, 3. the comparative

advantage of software and hardware in accomplishing various phases of the data processing.

A preliminary report on the results obtained to date is presently being written and should be ready for discussion in a month or so. The demonstration bit plane encoded memory system is still not quite complete. We expect to have all circuits complete and all bugs worked out before June.

### Ferrites

We have continued our study of relaxation processes in polycrystalline ferrites, which are relevant to the nondestructive readout of ordinary toroidal cores, and devices such as the biax memory element. Experimentally, the problem has been to work out instrumentation for making high-speed flux - time measurements near the rise and fall times of fast pulses. The signal processing must be sufficiently noise free to permit quantitative data to be taken. Also, since we are trying to take quantitative data from a sampling oscilloscope, the signals must be repetitive and free from time jitter. There is usually a complex pulse pattern required. One of the six pulses is usually derived from transmission line, discharged by a reed switch which has a large amount of time jitter. In spite of these problems, which have not yielded easily to solution, we are managing to get some useful data. We find, for instance that we can separate the relaxation into three components with different time constants, whose relative contributions depend on the remanent state of the core and the dimensions of the pulse used to produce it. Our objective is to correlate these properties with the physical processes taking place and the NDR properties of the materials.

From the theoretical standpoint, we have been studying the theory of elasticity, and magnetoacoustic resonance. It appears that magnetoelastic energy may play a significant part in the switching process along with anisotropy, exchange, and magnetostatic energy. From the theory of magnetoacoustic waves, we expect acoustic waves to be driven by spin waves of the same energy and wave number. With finite boundary conditions and anisotropic polycrystalline materials, it is not possible to calculate the magnetoelastic spectrum exactly. It is our present estimate however, that the polycrystalline nature of the material results in the generation of a broad spectrum of spin waves, and the magnetoacoustic resonances are selectively excited via the natural geometrical resonances.

In connection with our tunneling experiments on single crystals, we have examined some of our thin platelets in a microwave spectrometer to check the quality of the crystals. The platelets are one half to one millimeter across, and less than 1000 Angstroms thick. At k-band (about 25kmc) we have found a surprisingly large anisotropy in the linewidth which follows the cubic symmetry of the crystal. This phenomenon has not been reported in the literature before to our knowledge. There are a number of theoretical predictions of angular dependence of line width which do not fit our results even qualitatively. We believe that the likely explanation is the anisotropy of the magnetoelastic coupling coefficients. Quite unexpectedly, therefore, there is a close tie between this work and our studies of ferrite switching properties. A paper reporting our results is just being sent out for publication.

## Tunneling

Before December, the first draft of the doctoral thesis by A. J. Gruodis was written. It is centered on J-V characteristics due to insulator potential barriers and the contributions due to the band structure of the electrodes. The chapter titles and subheadings of this report give a fairly good idea of the nature of the work to be reported.

### Electron Tunneling Through Potential Barriers Between Normal Metal Electrodes

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Referneces

Our experimental setup has been insufficient to duplicate all of the experiments being done by the most prominent research groups in electron tunneling research. We have not been able to go to temperatures below liquid nitrogen ( $77^{\circ}\text{K}$ ). This requires a helium dewar system with provisions for pumping to low pressures, which will reduce the temperature from  $4.2^{\circ}$  to about  $1.5^{\circ}\text{K}$ . We have not been equipped to do second derivatives of  $J$  with respect to  $V$ , which are capable of detecting very small anomalies in the tunnel current. This requires a system for applying a modulation voltage to the variable d-c bias, a second harmonic reference generator, a lock-in amplifier for detecting the  $2^{\text{nd}}$  harmonic current component, and the necessary peripheral amplifiers for putting the data on an x-y recorder. We have been operating with an analog computation directly from a low frequency triangular wave of the junction current. Third, we have not been equipped to do experiments in high magnetic fields.

Although we are fundamentally interested in large effects at room temperatures, from the device point of view, these extended measurement techniques are necessary to check our predictions and to show the existence of effects even though they may be small.

A new sample configuration has been worked out for use in a magnetic field where the working space is very small. We hope to be able to work with the magnets which exist in the laboratories of our colleagues. Facilities for low temperature measurements and for second harmonic measurements are in the planning stage.